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ABSTRACT

Self-paced programed and audiovisual (AV) instructional materials covering portions of the Air Force course, Precision Measuring Equipment (PME) Specialist, were developed, administered, and evaluated as means of assessing the feasibility of individualizing the PME course as part of the Air Force's Advanced Instructional System (AIS). The materials for a 90-hour block of instruction, entitled Waveform Analysis, included printed and AV material and covered complex cognitive and performance skills. The mean written test score for the block was 80 percent (passing was 70 percent), but this was achieved with an average 31 percent reduction in training time. Trainees indicated a positive attitude toward the course. Similar results were obtained in trials with smaller blocks of time. The reduction in training time coupled with trainee achievement supports the feasibility of individualizing the PME course. The projected cost savings in excess of $40,000 a year argue strongly for the cost effectiveness of individualizing the entire PME course and other similar technical training courses. (Author/WH)

AFHRL-TR-74-46

AIR FORCE HUMAN RESOURCES LABORATORY

PRECISION MEASURING EQUIPMENT (PME) INDIVIDUALIZED INSTRUCTION

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AIR FORCE SYSTEMS COMMAND
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NOTICE

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This report has been reviewed and is approved.

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Approved for publication.

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Self-paced programmed and audio-visual (AV) instructional materials covering portions of Air Force Course, 3ABR32430-2, Precision Measuring Equipment (PME) Specialist, were developed, administered, and evaluated as means of assessing the feasibility of individualizing the PME course as part of the Air Force Advanced Instructional System (AIS). The materials for a 90-hour block of instruction, entitled Waveform Analysis, included printed and AV media and covered complex cognitive and performance skills. For this block, there was a 31% reduction in

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mean training time with all trainees achieving all criterion objectives. Trainees achieved 99% of the performance objectives on the first attempt. The mean written test score was 80.1% (the passing score was 70%). Three of the 35 trainees required remediation because of low written test scores. Trainee attitudes toward the materials and system as measured by an attitude scale were positive. The materials for three smaller course segments, 6, 6, and 9 hours, respectively, consisted of printed adjunct programs and covered cognitive skills. The reduction in training times were 60%, 70%, and 61%, respectively. The written test scores were 83%, 96%, and 99%. The reduction in training time coupled with trainee achievement supports the feasibility of individualizing the PME course as part of the AIS. The projected cost savings for 1,025 students of reduced course length resulting from the conversion of the 90-hour block into self-paced instruction is in excess of $40,000.00/yr. Such projected savings argue strongly for the cost-effectiveness of individualizing the entire PME course and other similar technical training courses.

SUMMARY

Problem

The Advanced Instructional System (AIS) has the objective of testing and evaluating the feasibility of large scale, computer-based instructional systems for Air Force training. This project investigated one of the AIS Courses, 3 ABR 32430-2, Precision Measuring Equipment (PME) Specialist. The specific objectives of this project were to demonstrate the feasibility of individualizing the PME course as part of the AIS, to provide instructional material development guidelines for use in the AIS, and to produce prototype materials adaptable for use in the AIS.

Approach

The approach to the problem is best described in terms of the four phases of its accomplishment. The Phase I steps were: delineation of criteria for selecting course segments for individualization, analysis of the PME course and selection of representative segments for individualization. The Phase II steps were analysis of selected segments, and selection of strategies and instructional media. Phase III steps were design and preparation of individualized instructional materials, instructional management procedures, and a computer adaptation rationale. The Phase IV steps were tryout and evaluation of the prototype materials.

Results

The learning materials were tried out on the then currently available PME classes. The materials for a 90-hour block of instruction included printed and audiovisual media and covered complex cognitive and performance skills. For this block there was a 31% reduction in mean training time with all trainees achieving all criterion objectives. Trainees achieved 99% of the performance objectives on the first attempt. The mean written test score was 80.1% (the passing score is 70%). Three of 35 trainees required remediation because of low written test scores. Trainee attitudes toward the materials and system as measured by an attitude scale were positive. The attitude scale has a range of 20-100 with 60 as neutral. The mean trainee attitude scale value was 78.4. Three smaller segments of instruction were also tried out. The materials were printed adjunct programs and covered cognitive skills. The normal group-paced times were 6, 6, and 9 hours. The reduction in training times were 60%, 70%, and 61%, respectively. The written test scores were 83%, 96%, and 99%. There were 5,615 man-hours of direct labor expended in developing the Block X materials and the smaller segments (111 hours of conventional instruction in all). The mean hours of effort expended per trainee contact hour was 79. Production costs for the Block X instructional materials (software and hardware) were $24,327.00.

Conclusions

The reduction in training time coupled with trainee achievement supports the feasibility of individualized PME as part of the AIS. No problems were encountered that would indicate otherwise. The design and development of the learning materials required close coordination with instructional staff experts. Face-to-face contact was required to preclude misunderstandings and collocation of personnel is recommended where possible. It is also desirable that the staff personnel involved in the development of instructional materials are also part of the staff used to try out the materials. Because the management of individualized instruction is not trivial, it is important that the new instructor roles be defined early and the instructors be trained to accomplish these roles. Even with this preplanning and training, a certain evolutionary change in roles takes place. During the tryouts it became necessary to provide a separate testing area for trainees taking written tests. The testing and trainee evaluation process has greater space and personnel requirements during tryouts than are needed after materials are formally implemented. It was also determined that equipment spares of all types are required to support individualized training.

Estimating the cost effectiveness of this type of effort can be done by making certain assumptions. The contract costs are known and trainee flows are defined in Air Force training flow charts. There are several available estimates of course costs. Using a two-year time period and a minimum training cost estimate (that used for the Air Force Resources Conservation Program), the projected savings for 1,025 students of reduced course length resulting from the conversion of Block X into self-paced instruction would be $188,457.53. Subtracting total contract costs and allowing a more than adequate maintenance allowance, a minimum savings of $40,000.00 per year would be realized. If trainee pay and allowances for the time saved were added, the savings would increase to $110,000.00 per year. Such projected savings for one block of instruction argue strongly for the cost effectiveness of efforts such as this.

PREFACE

This study was initiated by the Technical Training Division, Air Force Human Resources Laboratory (TT/AFHRL), Lowry Air Force Base, Colorado, under Program Element (PE) 63102F, Innovations in Training and Education (INNOVATE), Project 1193, Advanced Instructional System (AIS). Mr. Joseph Y. Yasutake was the Program Manager and Mr. Arnold L. Hanson was the task scientist. The technical work was accomplished by the Engineering Psychology Department, McDonnell Douglas Astronautics Company - East and the Product Service Department, McDonnell Aircraft Company, both of Saint Louis, Missouri, under Contract F33615-71-C-1846 from 1 July 1971 through 31 October 1973.

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INTRODUCTION

The Advanced Instructional System (AIS) is Project 1193 of PE 63102F, "Innovations in Training and Education, (INNOVATE)." The overall objective of Project 1193 is to design, develop, test and evaluate the feasibility of a potentially large-scale, computer-based instructional system for Air Force training and education. The AIS will be an integrated training system encompassing individualized, self-paced course materials, a variety of instructional media, and a computer training management subsystem.

Several technical training courses will be implemented under the initial AIS configuration. Among them is 3ABR32430-2, Precision Measuring Equipment (PME) Specialist, a course that involves complex cognitive concepts and electronic skills. Airmen are taught to maintain, calibrate, troubleshoot, and repair sophisticated equipment in laboratories whose standards are one level below those of the National Bureau of Standards. The work described in this report constitutes the initial effort in the development of the PME course as part of the AIS.

The specific tasks that we had to accomplish included developing prototype individualized instructional materials for segments of the PME course, and documenting the procedures utilized to provide individualization. The overall objectives were to:

a. demonstrate the feasibility of individualizing the PME course as part of the AIS;

b. provide instructional materials development guidelines for use in subsequent AIS efforts; and,

c. produce individualized instructional materials amenable to adaptation for eventual use as part of the integrated AIS.

Our approach for realizing these objectives consisted of four major groups of activities. These groups of activities and the order in which they were accomplished are as follows:

Phase I. Delineation of criteria for selecting course segments for individualization, analysis of the PME course and selection of representative segments for individualization;

Phase II. analysis of designated segments and selection of strategies and instructional media;

Phase III. design and preparation of individualized instructional materials, instructional management procedures, and computer adaptation rationale; and,

Phase IV. tryout and evaluation of the materials.

In the ensuing sections, the specific tasks that compromised each major group of activities are discussed in detail. Taken together, these tasks and the guidelines presented for accomplishing them constitute a model for the selective development and evaluation of self-paced, multimedia technical training materials.

SECTION II

DELINEATION OF CRITERIA FOR SELECTING COURSE SEGMENTS FOR INDIVIDUALIZATION, ANALYSIS OF THE COURSE, AND SELECTION OF SAMPLE SEGMENTS FOR INDIVIDUALIZATION

The tasks that comprised each of the three major activities in Phase I and the order in which they were carried out was as follows:

ACTIVITIES	TASKS
Delineation of Criteria for Selecting Course Segments for Individualization	1. Develop Selection Criteria Based on Study Objectives.
Analysis of the Course	2. Gather, Review, and Analyze Relevant Course and Job Documents.
	3. Isolate Important Trainee Characteristics.
	4. Examine the Training Environment.
Selection of Sample Segments for Individualization	5. Select Sample Segments for Individualization on the Basis of Information Gathered in Tasks 1 through 4.

Detailed descriptions of how these tasks were accomplished are presented in the pages that follow.

DELINEATION OF CRITERIA FOR SELECTING COURSE SEGMENTS FOR INDIVIDUALIZATION

TASK 1: DEVELOP SEGMENT SELECTION CRITERIA

In keeping with our objective of demonstrating the feasibility of individualizing the PME course as part of the AIS, we developed the following criteria for selecting course segments for individualization:

1. Segments chosen must sample the full range of skills and knowledges required in the PME course.

2. Segments chosen must sample the full range of media requirements for the PME course.

3. Segments chosen must contain skills and knowledges which are prerequisities for accomplishing high frequency tasks on the job.

4. Segments chosen must contain skills and knowledges which are essential to projected as well as current high frequency job tasks.

5. Segments chosen must be able to be implemented without disrupting trainee flow through nonselected segments.

Having defined the selection criteria, our next task consisted of analyzing the PME course so that segments meeting these criteria could be identified.

ANALYSIS OF THE COURSE

TASK 2: GATHER, REVIEW, AND ANALYZE RELEVANT COURSE AND JOB DOCUMENTS

The first step in the course analysis process involved gathering PME course and job documents. Our preliminary inventory included the following types of documents:

- Course Chart
- Specialty Training Standard (STS)
- Plan of Instruction (POI)

- o Student Study Guides
- o Student Workbooks
- o Occupational Survey Report (OSR)
- o Programmed Texts
- o Student Handouts

Of these documents, the Course Chart, the POI, the Student Study Guides and Workbooks, the STS, and the OSR proved most useful in providing an overview of the PMF course. The Course Chart contained a description of each block in the course in terms of the specific topics covered and the amount of classroom time devoted to each topic. The POI was used to identify the critical intermediate and terminal behaviors in each block of the course, as well as the media and reference materials currently utilized. The Student Study Guides and Workbooks gave us a feel for the hierarchical relationships that exist within and between blocks, and a general idea of the strategies currently employed in constructing printed materials. The STS provided specific proficiency requirements for all terminal and intermediate behaviors. Finally, task, frequency of performance, and total time data from the OSR were utilized in a preliminary determination of those terminal and intermediate behaviors listed in the POI that were important from the standpoint of performance on the job.

TASK 3: ISOLATE IMPORTANT TRAINEE CHARACTERISTICS

The second step in the course analysis process was based on the assumption that a primary consideration in designing instruction is who the program is for and what these trainees will be like when they start the program. The characteristics of the target population have implications for virtually all aspects of instructional design and, for this reason, it was important to "define" the target population at an early stage in the design activities.

The specific characteristics of the target group, including the degree of homogeneity or heterogeneity, provide information needed to most effectively make decisions in such areas as the following:

1. Knowledges and skills to exclude because the target group possesses them.
2. Entry competencies to plan for in knowledge-skill areas pertinent to the program.

3. Probable areas for prerequisite deficiencies.

4. Attitudes to contend with, positive and negative, including level of achievement motivation.

5. Probable differences in learning rates or amounts of learning per unit of time.

6. Appropriateness of different instructional strategies, including media applications.

The importance of such information for decision-making was fully understood in the PME project. Accordingly, steps were taken to obtain "readily available" information regarding the target population for the new individualized, multimedia PME course segments at Lowry Air Force Base.

The following types of information about the target population were thought to be important:

1. Size and Location

    a. Size of target population and rate of increase or decrease.

    b. Location of the group.

    c. The instructional "unit" size (e.g., 120 trainees, 12 per class and 10 classes), if one currently exists.

2. Aptitudes and Achievement

    a. Percentile scores on indices of the Airman Qualifying Examination (AQE) relevant to the general and specific abilities demanded by the PME course.

    b. Scores (mean, range, and standard deviation) on standardized national and/or validated local achievement tests.

Information regarding the size and location of the target population and their percentile scores on indices of the AQE relevant to the PME course was supplied by the instructors at the PME school.

Initially, the available information was utilized to get an idea of how many trainees would interact with the inidividualized materials at any one time in each course block, and some feel for the skill and aptitude ranges of these groups. Eventually, this information was utilized to make detailed materials design decisions with regard to assumed entry skills or deficiencies, learning rates, and the appropriateness of various instructional strategies.

TASK 4: EXAMINE THE TRAINING ENVIRONMENT

The third step in the course analysis process involved surveying the classroom facilities and equipment inventory at the PME laboratory. There were twelve classrooms, one each for Blocks I through X, and two for Block XI. The rooms ranged in size from 700 sq. ft. to 1200 sq. ft., and all were equipped with 117 volts AC, 60 Hz wiring. Classrooms devoted to academic topics (the initial course blocks) contained tables and chairs. Those classrooms devoted to "hands-on" performance contained workbenches in addition to tables and chairs. In both types of classrooms, there was ample workspace for individual utilization of printed and audiovisual instructional materials.

Calibration standards and applied measurement trainers are the major equipment items utilized in the PME course. There were limited numbers of some pieces of equipment; however, trainees typically worked individually or in pairs in those blocks where such equipment was utilized. Our brief survey indicated that most course segments could be individualized without disrupting trainee flow through nonselected segments or drastically altering the physical environment.

The review and analysis of course and job documents, trainee characteristics, and the training environment gave us a good feel for the broad range of skills and knowledges that the PME graduate must possess, an idea of the number and caliber of trainees that were entering the course, and a preliminary list of training environment resources and constraints. This information was utilized in conjunction with the criteria developed in Task 1 to select course segments for individualization.

SELECTION OF REPRESENTATIVE SEGMENTS FOR INDIVIDUALIZATION

TASK 5: SELECT SEGMENTS FOR INDIVIDUALIZATION

Air Training Command (ATC) specified that Block X (Waveform Analysis) of the PME course be converted into individualized instructional sequences. This block represents 90 hours of instruction, much of which is of the "hands-on" variety. Interviews with PME Master Instructors indicated that Block X satisfied selection criteria 3 and 4 (i.e., the skills and knowledges contained in the block were essential to current and projected high frequency job tasks). Our analysis indicated that Block X also satisfied selection criteria 2 and 5 (i.e., media requirements were representative and trainee flow through nonselected segments would not be hindered). To insure that the full range of skills and knowledges required in the course were represented (selection criterion 1), we selected an additional 24 hours of instruction from Blcoks IV and VI that were primarily academic (i.e., theoretical) in nature. The specific topics chosen in these blocks were: Block IV - Semiconductor Physics (6 hours) and NPN and PNP Transistors (6 hours); and Block VI - Logic Circuits (9 hours). PME Master Instructors reviewed and approved these selections.

The three lessons from Blocks IV and VI dealt exclusively with knowledges and contained no performance tasks. They were used primarily as a test-bed for our programmed instruction technique. Consequently, the design, development, and evaluation of Block X materials is emphasized in this report.

SECTION III

TRAINING ANALYSIS AND MEDIA SELECTION

The tasks that comprised the two major activities in Phase II and the order in which they were carried out was as follows:

ACTIVITIES	TASKS
(Phase I)	(1, 2, 3, 4, 5)
Detailed Analysis	6. Conduct Training Task Analysis
	7. Review Learning Objectives
	8. Examine and Update Test Items
	9. Specify Instructional Sequence
	10. Specify Presentation Strategies
Media Selection	11. Develop Rationale for Selecting Media
	12. Select Media

Detailed descriptions of how these tasks were accomplished are presented in the paragraphs that follow.

DETAILED ANALYSIS

TASK 6: CONDUCT TRAINING TASK ANALYSIS

The first step in the detailed analysis of selected segments involved reviewing the POI and STS to identify critical skills and knowledges. Block X was comprised of five major segments. For each segment, instructional topics were listed. For each topic, a terminal behavior or list of terminal behaviors was identified. These terminal behaviors comprise the tasks that the trainee has to be able to perform. A list of content statements was also generated for each topic. These content statements describe, in narrative form, what the trainee has to know in order to perform the tasks.

Once required tasks and contents had been identified detailed task and content analyses were compiled. Each task was broken down into the distinctly different steps that comprised it. Each step was put in sentence form and the steps were ordered sequentially. The set of steps then constituted a procedure which could be used to perform a "hands-on" task. Task analysis data were generated by viewing videotapes of experts performing the tasks in question, observing instructors in "live" demonstrations, and reviewing technical manuals that dealt with task performance.

To identify critical content, we asked the following question: "What would the trainee have to know in order to perform the task in question?" Content analyses were written in the same manner that conventional subject matter outlines are written. Titles and subtitles of one or few words were utilized, with the titles and subtitles arranged in a sequence that corresponded to the order in which they were to be taught. Content analysis data were taken from the existing POI, and the tests and training materials referenced in it. The content ultimately included in the materials was selected in light of the tasks that the trainee had to perform and the terminal behaviors that he had to exhibit. Only information (i.e., content) that supported task performance was included.

Preliminary training task analysis results were reviewed with Master Instructors from the PME school. Detailed task and content data were revised and updated to insure accuracy and completeness. Sample task and content analyses are shown in Appendix A.

TASK 7: REVIEW AND UPDATE LEARNING OBJECTIVES

The second step in the detailed analysis of selected segments involved reviewing and updating criterion and enabling objectives/teaching steps on the basis of task and content analyses. Existing objectives were reviewed to isolate the following types of deficiencies:

- o Inadequacy of form (i.e., objective does not clearly state the behavior required, the conditions, or the standards of task performance).

- o Inadequacy of content (i.e., objective is too broad or too narrow to reflect the task which it is to cover).

Objectives were modified if they were inadequate in form or in content, or deleted if they were unnecessary. Modifications and deletions were done under the cognizance of the PME Master Instructors.

Where required, new objectives were written. The questions asked in the process of deciding whether or not to create a criterion objective for a specific task were as follows:

- o Is the performance critical and completely self-contained? If yes, answer question below.

- o Is the performance complex enough that it warrants its own objective? If yes, write a new criterion objective.

The guideline used in deciding if a criterion objective required enabling objectives/teaching steps was as follows:

- o Does the criterion objective as stated assume some prerequisite skill or knowledge for terminal performance? If yes, write a new enabling objective/teaching step.

New criterion and enabling objectives/teaching steps were reviewed and approved by the PME Master Instructors. A sample learning objective is shown in Appendix B.

TASK 8: EXAMINE AND UPDATE TEST ITEMS

The third step in the detailed analysis of selected segments involved reviewing and updating test items. We decided that a criterion test item had to be essentially a "mirror image" of the behavioral objective for which it was prepared and it had to be an objective measure. In other words, the exact criterion behavior specified in the behavioral objective was to actually be a part of the learning objectives. Every criterion behavior stated in the objective had to be explicit, measurable, feasible, unambiguous, etc., because that behavior, perhaps exactly as stated, was the "answer" to the associated test item.

The primary advantage of this "mirror image" approach involved the content validity of the test items. It allowed us to determine whether or not the test items were measuring the same behaviors as called for by the behavioral objectives. This approach enabled "face validity" judgments to be unequivocally made by instructional designers. Existing test items were reviewed and updated, and some new test items were created for use as embedded questions or as supplements to existing examinations. The updated and new test items were reviewed and approved by the PME Master Instructors.

Performance and written tests were constructed for use in evaluating trainee attainment of criterion behaviors. The performance tests or criterion-reference checks were to be administered at the end of lessons and consisted of having the trainee demonstrate proficiency on some training task, such as "calibrating the 545." Trainees had to demonstrate complete mastery of the task in question before being allowed to continue.

Written tests were of two types. One type, called "demand-response", consisted of a series of short questions embedded within the PI text. These questions dealt with important information, and had to be answered correctly before the trainee could continue. The other type of written test was to be administered when all lessons were completed and was composed of test items that, as closely as possible, reflected criterion performance. This test was called the end-of-block examination.

TASK 9: SPECIFY INSTRUCTIONAL SEQUENCE

The fourth step in the detailed analysis of selected segments involved determining the sequence of instructional activities, that is, the order in which trainees would interact with units of content. The existing POI proved to be an effective first step in sequencing the instruction. It provided the initial, "general" sequence of the topics that comprised Block X.

An effective second step in sequencing was the preparation of training task analysis lists and learning objectives. Identifying training tasks, preparing criterion and enabling objectives, and examining the relationships among criterion objectives and their associated enabling objectives provided the information necessary to sequence the block into a hierarchy of competencies. Block X was divided into the following five major segments:

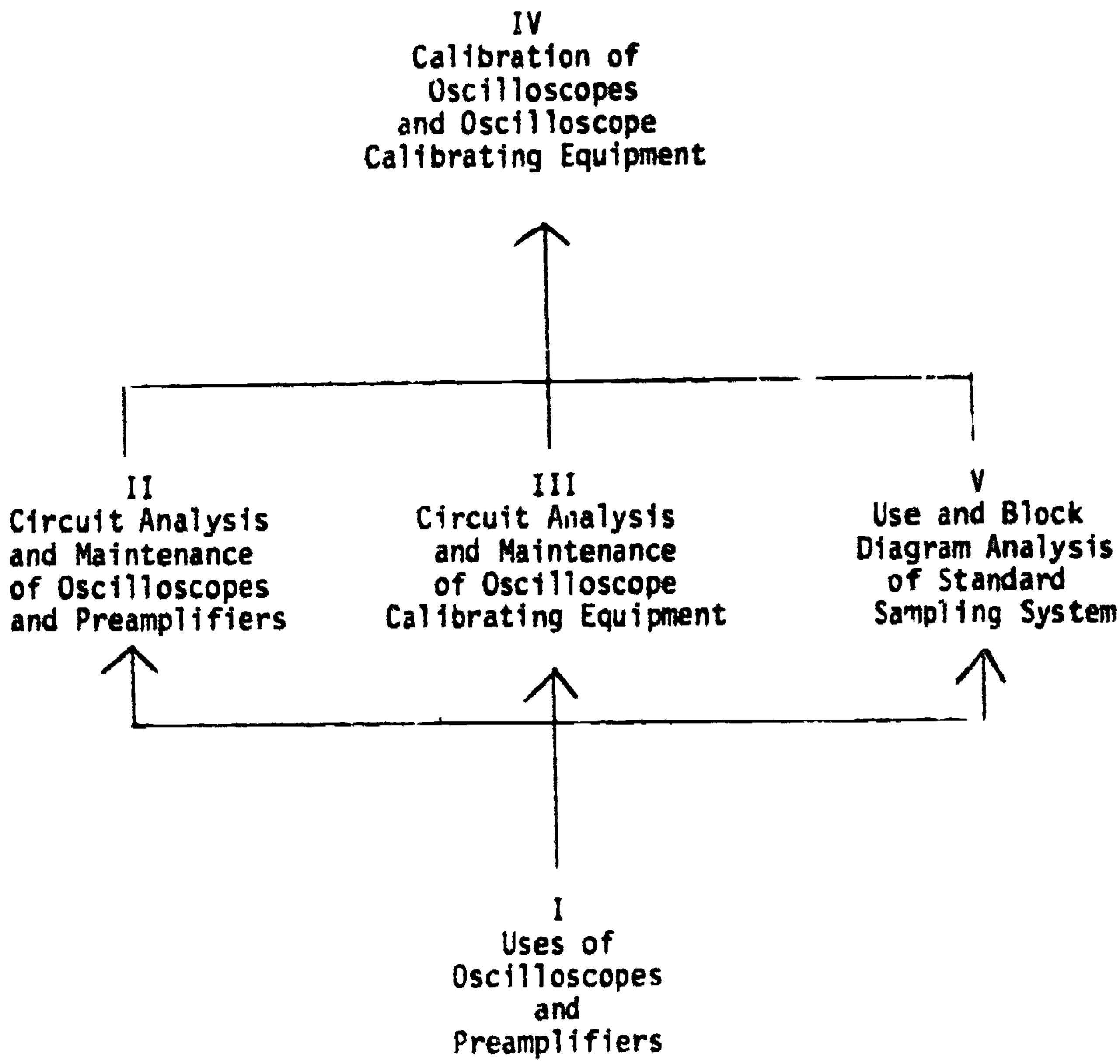


FIGURE 1. Major groupings of objectives.

- Uses of Oscilloscopes and Preamplifiers
- Circuit Analysis and Maintenance of Oscilloscopes and Preamplifiers
- Circuit Analysis and Maintenance of Oscilloscope Calibrating Equipment
- Calibration of the Oscilloscope and Oscilloscope Calibrating Equipment
- Use and Block Diagram Analysis of Standard Sampling System

Each of these segments was, in turn, then broken down into sections (lessons). A section or lesson was a self-standing unit of instruction that dealt with a criterion objective or group of closely related criterion objectives.

The five major groups of objectives represented the five major concept areas or segments of Block X and were related in the fashion illustrated in Figure 1. Note that the segments are hierarchically ordered. It was necessary for a trainee to achieve the objectives of Segment I before he could begin either Segment II or Segment III or Segment V. Similarly it was thought that the trainee had to have achieved the objectives of Segments II, III, and V before he was qualified to begin Segment IV.

In terms of course presentation, then, a trainee could study the segments in the orders of sequences shown in Figure 2. The decision to allow all acceptable sequences was based on the fact that limited numbers of test and calibration equipments would be available during evaluation of the prototype instructional materials. Additionally, there were alternative lesson sequences for certain of the segments. A flowchart showing acceptable lesson sequences appears in Appendix C. Multiple routes through the materials constituted a mechanism for maintaining trainee flow and minimizing training time in the face of limited equipment inventory.

SEQUENCE A (ASCENDING ORDER)	SEQUENCE B (ASCENDING ORDER)	SEQUENCE C (ASCENDING ORDER)	SEQUENCE D (ASCENDING ORDER)	SEQUENCE F (ASCENDING ORDER)	SEQUENCE F (ASCENDING ORDER)
IV	IV	IV	IV	IV	IV
V	II	III	II	V	III
III	V	II	III	II	V
II	III	V	V	III	II
I	I	I	I	I	I

FIGURE 2 SEGMENT SEQUENCES

TASK 10: SPECIFY PRESENTATION STRATEGIES

The fifth and last step in the detailed analysis of segments involved specifying presentation strategies. Since one of our major objectives was to test the feasibility of individualizing a portion of the PME course, we decided that each trainee should largely control his own learning pace, provided he is progressing at some minimally acceptable rate, and that a variety of instructional media should be provided. In order to facilitate self-pacing, the instructional materials were to be prepared in such a way that each trainee could control, within limits, the amount of time that he spent interacting with each set of lesson materials. Additionally, we decided that the materials were to be prepared in such a way that each trainee would:

a. receive instruction that was "structured" to provide information regarding the skills and knowledges to be mastered,

b. have the opportunity to actively practice the skills and knowledges to be mastered, and

c. receive feedback regarding the adequacy of his performance during practice.

The impact of these strategies decisions on the selection of instructional media and the construction of instructional materials are detailed in the paragraphs that follow.

MEDIA SELECTION

TASK 11: DEVELOP RATIONALE FOR SELECTING MEDIA

Three factors were considered in choosing instructional media for Block X lessons. The first factor was the type of learning that the lesson objective(s) entailed. The second factor was the necessity (and desirability) of producing self-paced and audio-visual (AV) materials. The third factor was the constraints under which the materials were being developed. Consideration of each of these factors was formally represented as one stage in a three-stage media selection process (cf. Figure 3).

Stage 1 involved classifying the type of learning entailed in the lesson objective(s) as either the acquisition of a knowledge or the acquisition of a skill. Two decisions were then made. One was that some form of self-paced programmed instruction was a suitable vehicle for imparting knowledges of the type required in the PME course. The other was that some form of instruction which combined demonstration and performance was a suitable vehicle for imparting skills of the type required in the PME course.

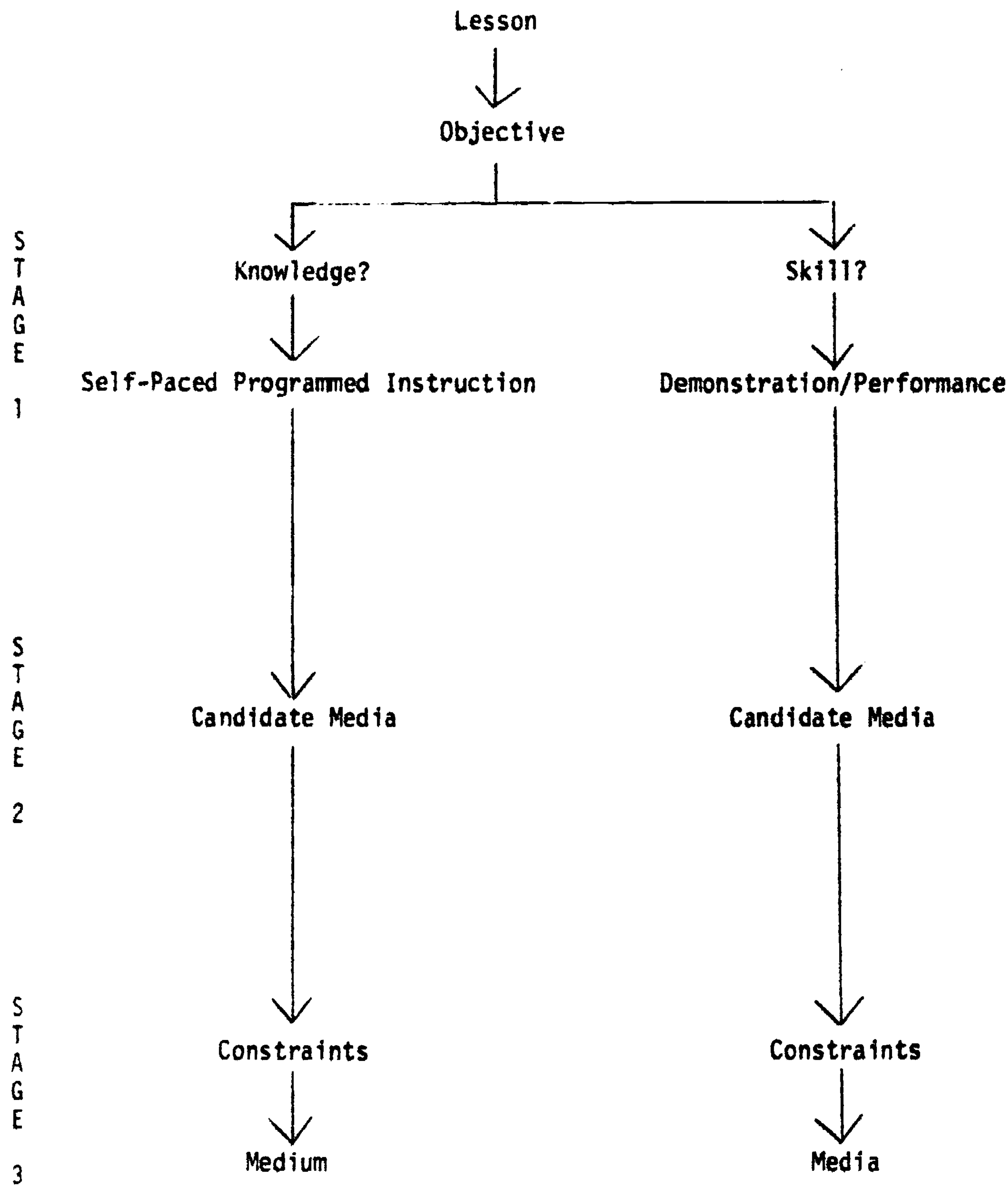


FIGURE 3. Three-stage media selection process.

Stage 2 involved identifying candidate media and media mixes that could be used to implement self-paced programmed instruction for "knowledge" lessons and demonstration/performance-based instruction for "skill" lessons. For example, self-paced programmed instruction could have been implemented using printed materials exclusively, audio tapes and printed workbooks, or microfiche and chemically-treated answer sheets. Demonstration/performance-based instruction could have been implemented using various AV media, either singularly or in combination, live demonstrations and supervised practice, or computer-assisted instruction.

Stage 3 involved defining the constraints that would impact media selection. Learning proficiency and cost were the primary constraints considered in the choice of a medium for implementing self-paced programmed instruction for "knowledge" lessons. The slection of the medium was made with a view toward individualizing instruction and maximizing learning, while minimizing material production, reproduction, and revision costs. Two constraints influenced the choice of media used to implement the demonstration/performance paradigm for "skill" lessons. The first constraint arose as a result of our initial decision to produce self-paced programmed instruction for "knowledge" lessons. We assumed that the trainees would progress through the self-paced materials at different rates and we abandoned the traditional notion of the instructor confronting the group with "live" demonstrations for "skill" lessons. This argued for "canned" demonstrations that could be made available to trainees on an individual basis, and dictated our choice of AV media for "skill" lessons. The second constraint, the desirability of utilizing AV media that were compatible with presentation hardware of demonstrated reliability already in the Air Force inventory, helped narrow the range of AV media under consideration.

TASK 12: SELECT MEDIA

The primary medium selected for "knowledge" lessons was programmed text. The primary media chosen for "skill" lessons were filmstrip/sound and motion picture programs. Supplementary media included videotape programs, AV scripts, and a picture book containing annotated equipment photographs.

SECTION IV

PREPARATION OF MATERIALS, DEVELOPMENT OF INSTRUCTIONAL MANAGEMENT PROCEDURES, AND DESIGN OF A COMPUTER ADAPTATION RATIONALE

The tasks that comprised the major activity in Phase III and the order in which they were carried out was as follows:

ACTIVITIES — TASKS

(Phase I) — (1, 2, 3, 4, 5)

(Phase II) — (6, 7, 8, 9, 10, 11, 12)

Instructional Materials Development —
13. Prepare Instructional Materials
14. Develop Instructional Management Procedures
15. Delineate Computer Adaptation Rationale

Detailed descriptions of how these tasks were accomplished are presented in the pages that follow.

TASK 13: PREPARE INSTRUCTIONAL MATERIALS

A programmed text was developed for each of the five segments that comprised Block X. Each text consisted of programmed lessons, with each lesson containing all of the information necessary to master one of the PME knowledges identified during the training analysis. Lessons were based on the content analyses completed in Phase II, and were narrative in format. Underlining and embedded questions were used extensively. Underlining critical content within lessons provided "structured" instruction in the sense that knowledges to be mastered were highlighted and emphasized. Questions were embedded within lessons to give trainees the opportunity to actively practice the knowledges to be mastered. The answers to the embedded questions were placed at the end of each lesson to provide feedback regarding the adequacy of performance during practice.

Sound/filmstrip (Audiscan) programs were prepared for the bulk of the "skill" lessons. Using the task analyses completed in Phase II, scripts were written outlining every distinct step listed in each task analysis. For each of these steps, a scene was staged with the appropriate test equipment and, in some cases, an actor. Each scene was then photographed; and 35MM color slides produced and placed in an order that corresponded to the sequence in which the steps had to be performed. The slides and script were used, along with the appropriate test equipment, in a "dry run" of the procedure. PME Master Instructors observed the "dry run," recommended changes where appropriate, and examined the revised product prior to certifying the technical accuracy of the slides and script. Each slide package was rephotographed as a 16MM filmstrip. The script was narrated onto 1/4 inch magnetic tape and used as a master. Copies were made of both the filmstrip and the narrative and the copies were loaded into Audiscan cartridges.

The sound/filmstrip programs provided "structured" instruction in the sense that each PME task was fully proceduralized; i.e., each step was clearly and concisely presented. Using actual PME equipment, trainees performed each step in each procedure by imitating the actions seen on the screen, thereby actively practicing the skills to be learned. Feedback slides were included in each program to provide a model or standard against which trainees could periodically assess the adequacy of their responses.

Motion pictures (A. B. Dick programs) were produced for those "skill" lessons that involved, as an integral component of instruction, the recognition of systematic changes in dynamic display patterns in response to specific equipment adjustments. Using the task analyses completed in Phase II, scripts were written detailing each step in each task. For each of these steps a scene was staged with the appropriate test equipment. A 16MM motion picture camera and color film were used to photograph an actor making the required equipment adjustments as well as the dynamic scope patterns that resulted from those adjustments. The film was edited, and used, along with the script, in a "dry run" of the procedure. PME Master Instructors observed the "dry run", recommended changes where appropriate, and examined the revised product prior to certifying the technical accuracy of the film and script. A "narrative-over-picture" procedure insured proper synchronization of the master. Super 8MM magnetic strip reduction prints were made and loaded into A. B. Dick cartridges. The A. B. Dick programs provided for "structured" instruction, active practice, and feedback in a manner essentially identical to that of the Audiscan (sound/filmstrip) programs.

A book of equipment photographs was also compiled. Each piece of PME equipment was photographed, along with those specific areas of each piece that contained calibration or test points, with high-resolution color film. The films were developed and enlarged to 8 1/2 x 11 color prints. Reference lines and numbers were superimposed on those prints containing calibration or test points by placing acetate overlays on the original prints and rephotographing them. These films were processed and enlarged to 8 1/2 x 11 color prints. Written descriptions of calibration or test points were referenced to the annotated photos. Trainees were to use the picture book to familiarize themselves with Block X equipments. Additionally, the picture book could be used in conjunction with Audiscan and A. B. Dick scripts to preview AV sequences.

Finally, each Block X procedure being performed by a PME Master Instructor was videotaped. The start/stop and rewind features of the videotape presentation devices made it possible for trainees to preview an AV sequence or to selectively review a portion or portions of an AV sequence as often as desired and on a task step-by-step basis if necessary.

TASK 14: DEVELOP INSTRUCTIONAL MANAGEMENT PROCEDURES

The pre-AIS implementation of Block X in an individualized, self-paced mode necessitated the development of procedures for manually managing trainees and resources. Our analysis indicated that instructors would be performing the following instructional management functions:

- o administering and scoring tests;
- o making lesson assignments; and,
- o monitoring trainee progress.

In addition to these management functions, the instructors would continue to provide tutorial and remedial aid for individual trainees.

No special procedures were developed to aid in the administration and evaluation of criterion reference checks (i.e., performance tests) and written or oral tests given at the end of "knowledge" lessons. Scoring keys and templates were devised for hand processing both forms of the end-of-block knowledge test.

Two charts were developed for instructor use in making lesson assignments. The first, the Lesson Flowchart, depicted a lesson network that specified acceptable alternate paths through Block X. The second, the Trainee Progress Flowchart, shown in Appendix D, contained a record of the lessons he had completed, the amount of time expended in completing each lesson, and the lesson on which he was currently working.

A trainee's performance on a criterion check, written test, or oral test given upon completion of a lesson was used by the instructors to determine whether he required remedial instruction or was ready for a new assignment. If a trainee required remedial instruction, he was directed back to a programmed text for "knowledge" lessons or to a videotape program for "skill" lessons. Upon completing the remedial assignment he was retested. If his performance was not acceptable, he was given additional remedial aid. When his performance was acceptable, he was considered ready for a new assignment. When a trainee was judged ready for a new assignment, the Lesson Flowchart was examined to identify those lessons that he could take next. If the options were a "skill" and a "knowledge" lesson, the instructors checked to see if the appropriate resources (AV and test equipment) were available for the "skill" lesson. If the resources were immediately available, the trainee was assigned to the workbench. If the resources were not immediately available, the instructors checked the Trainee Progress Flowchart to see if someone was close to completing a "skill" lesson. If someone was going to be tested soon, the trainee awaiting a new assignment was told to use the photo book or a videotape program to preview the next lesson. If the resources were not immediately available and no one was going to be tested soon, the trainee was directed to a "knowledge" lesson. Lesson presentation sequences were limited to the options delineated in the Lesson Flowchart. Each trainee, of course, was required to complete all of the Block X lessons - only order of completion was allowed to vary across trainees.

In addition to being used in the prescriptive process, the Trainee Progress Flowchart was used to monitor the performance of individual trainees. A trainee's performance history in terms of the number of lessons completed and the amount of time expended completing each of those lessons could be compared to similar data for his classmates. These comparisons allowed the instructors to identify trainees who were experiencing difficulty and to isolate those lessons on which the group was expending a great deal of time. Finally, the Flowchart summarized performance data in an easy-to-read format so that individual or group data could be easily captured for report generation purposes.

TASK 15: DELINEATE COMPUTER ADAPTION RATIONALE

The instructional management functions mentioned in the preceding section are all computer-compatible. The first function, test scoring, serves as basis for the other two functions. The second function, making lesson assignments, calls for the application of decision rules to performance data to generate instructional prescriptions. The third function, monitoring trainee progress, requires that the performance data be analyzed and manipulated so that performance and time on lesson is accessible on an individual, group, or class basis. The requirements for computerizing the management of Block X in an individualized, self-paced mode are described in the paragraphs that follow.

Test Scoring - Computerized test scoring would require the development of programs to score multiple choice, true/false and constructed-response tests as well as performance checklists. Performance checklists would have to be standardized and made to resemble objectively-scored tests from a format standpoint. Constructed-response tests could not be scored unless there was a human interface between the tests themselves and the data input to the computer or the tests were read and scored in a CAI mode.

Making Lesson Assignments - Additional programming would be required to enable the computer to compare trainee performance and time data (single lesson or cumulative lesson data) with validated instructional treatment data. A scheduling-resource allocation program would provide information regarding limited resources currently available and the forecasted demand for those limited resources. Decision rules would be input to the computer. These statements of logical and computational operations, in conjunction with formatting statements, would process performance and resource availability data in such a way as to output prescriptions.

Monitoring Trainee Progress - The test scoring programs would require the addition of statements that would cause the performance and time data to be stored in files which permit a flexible retrieval capability. In addition to trainee performance and time data, information pertaining to instructional alternatives and previously encountered instructional treatments could be stored. A report generation program would be constructed which would query the appropriate files and output performance, time, and instructional treatment data on a lesson or cumulative lesson basis for an individual trainee, selected trainees, or the entire group of trainees currently interacting with the system.

SECTION V

EVALUATION OF THE PROTOTYPE INSTRUCTIONAL MATERIALS AND SPECIFICATION OF MANHOURS EXPENDED AND CONVERSION COSTS

The tasks that comprised the major activity in Phase IV and the order in which they were carried out were as follows:

ACTIVITIES	TASKS
(Phase I)	(1, 2, 3, 4, 5)
(Phase II)	(6, 7, 8, 9, 10, 11, 12)
(Phase III)	(13, 14, 15)
Evaluation of the Prototype Materials	16. Describe Formative Evaluation and Validation process
	17. Evaluate the Prototype Instructional Materials
	18. Specify Manhours Expended and Conversion Costs

Detailed descriptions of how these tasks were accomplished are presented in the pages that follow.

TASK 16: DESCRIBE FORMATIVE EVALUATION AND VALIDATION PROCESS

Formative evaluation and validation of the Block X prototype self-paced materials involved an iterative process of reviews, tryouts, instructor debriefings, and revisions. The process is depicted graphically in Figure 4. The initial step in the process involved having technical experts review the prototype lessons and suggest revisions. The prototypes were revised and 10 trainees then used them in an operational classroom setting. Data such as trainee performance on criterion-reference checks and the end-of-block examination as well as training time per lesson and total training time and trainee attitudes toward the self-paced materials were utilized in developing a debriefing agenda for use with PME Master Instructors. The debriefing dealt with problems encountered in the small-group tryout and led to suggestions for revising prototype materials and manual management procedures prior to exposing large groups of trainees to the revised prototypes. The prototypes underwent a second revision and 35 trainees used them in an operational classroom setting. Learning and attitudinal measures and training times were utilized in developing a final debriefing agenda for use with PME Master Instructors. Suggested revisions were made and the lessons were then considered operational.

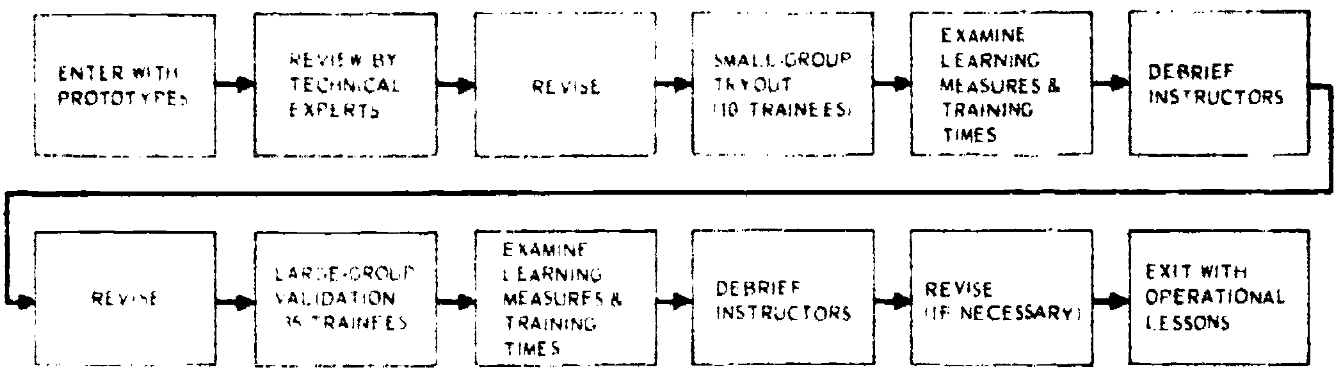


FIGURE 4 BLOCK X FORMATIVE EVALUATION AND VALIDATION PROCESS

TASK 17: EVALUATE THE PROTOTYPE INSTRUCTIONAL MATERIALS

Fourteen trainees utilized the programmed instruction lessons constructed for the Semiconductor Physics and Transistor Theory segments of Block IV, and 12 trainees utilized the programmed instruction lesson constructed for the Logic Circuit segments of Block VI. The results of these tryouts are shown in Table 1. In general, the data indicate that the trainees were able to master the materials in much less time than was conventionally devoted to the topics in question. We concluded that our programmed instruction format was appropriate for imparting knowledges of the type required in the PME course.

TABLE 1
TRYOUT RESULTS – BLOCK IV & BLOCK VI SEGMENTS

	NO. OF TRAINEES	GROUP TEST SCORE	CONVENTIONAL COURSE HOURS	$\bar{X}$ TIME TO COMPLETE
BLOCK IV				
SEMICONDUCTOR PHYSICS	14	83%*	6 HRS.	2 HRS., 30 MINS.
TRANSISTOR THEORY	14	96%**	6 HRS	1 HR., 42 MINS.
BLOCK VI				
LOGIC CIRCUITS	12	99%***	9 HRS.	3 HRS., 32 MINS.

* 7 QUESTIONS ON END-OF-BLOCK EXAMINATION
** 7 QUESTIONS ON END-OF-BLOCK EXAMINATION
*** 6 QUESTIONS ON END-OF-BLOCK EXAMINATION

The 10 trainees who took part in the Block X small-group tryout completed the materials in 83% of the normal block time, thereby achieving a mean time savings of 17%. Summary statistics for Block X small-group tryouts are shown in Table 2. As a group, the trainees successfully completed 269 out of 270 criterion-reference checks (27 checks/man) on the first try (overall mean = 99%). They achieved a mean end-of-block examination score of 77.4%, with all trainees passing the end-of-block examination on the first try. Trainee attitudes toward the self-paced materials were assessed anonymously upon completion of the end-of-block examination using the 20-item scale shown in Appendix E. All negative items were scored positively. A score of 60 would have been indicative of a completely neutral attitude toward the self-paced materials. The mean score was 78.4%, indicating that trainee attitudes toward the self-paced materials were highly favorable. Test scores, attitude data, and time saved are shown in Appendix F.

TABLE 2
SMALL-GROUP TRYOUT RESULTS – BLOCK X

BLOCK X	NO. OF TRAINEES	$\bar{X}$ TEST SCORE	CONVENTIONAL COURSE HOURS	$\bar{X}$ TIME TO COMPLETE	$\bar{X}$ TIME SAVED	% TIME SAVED
WAVEFORM ANALYSIS	10	77.4*	90 HRS.	74 HRS., 24 MINS.	15 HRS., 36 MINS.	17%

*60-ITEM END-OF-BLOCK EXAMINATION

The 35 trainees who took part in the large-group validation completed the revised Block X materials in 69% of the normal block time, thereby achieving a mean time savings of 31%. Summary statistics for Block X large-group validation are shown in Table 3. This was a

TABLE 3
LARGE-GROUP VALIDATION RESULTS – BLOCK X

BLOCK X	NO. OF TRAINEES	$\bar{X}$ TEST SCORE	CONVENTIONAL COURSE HOURS	$\bar{X}$ TIME TO COMPLETE	$\bar{X}$ TIME SAVED	% TIME SAVED
WAVEFORM ANALYSIS	35	80.1	90 HRS.	62 HRS., 24 MINS.	27 HRS., 36 MINS.	31

definite improvement over the time savings achieved by the 10 trainees who took part in the small-group tryout. The improvement may have been due to revisions made in the prototype materials following small-group tryout, or the added experience of the instructors in administering self-paced instruction. Most probably it was due to some combination of these two factors.

As a group, the trainees who took part in the large-group validation successfully completed 937 out of 945 criterion-reference checks (27 checks/man) on the first try (overall mean = 99%). There was no difference between their performance and that of the trainees who took part in the small-group tryout. It should be noted that criterion-reference checks were conducted on an individual basis during the small-group tryout and large-group validation. In the conventionally-taught block, trainees work and are tested in pairs. The instructors felt that performance testing was much more rigorous and that they were better able to assess a trainee's competence when he was tested on an individual basis. Additionally, trainees were able to spend more time working with the equipment in the self-paced mode of instruction.

The large-group validation trainees achieved a mean end-of-block examination score of 80.1%, with 32 of the 35 trainees passing on the first try. Their mean examination score represented a slight improvement over that achieved by the trainees who took part in the small-group tryouts. The three trainees who failed the end-of-block examination on their first try subsequently passed an alternate form of the examination after completing their remedial assignments. The mean score of the 35 large-group validation trainees on the attitude scale was 77.4%, indicating that their attitude toward the self-paced materials was highly favorable. Test scores, attitude data, and time saved are shown in Appendix G.

Background data were obtained on 47 trainees who received conventional instruction in Block X in nearly the same time frame as the 35 validation trainees. The data for the 35 validation trainees and the other 47 trainees were compared with respect to general and electronic AQE, and Block I, X, and total test scores (these data are shown in Appendix H). The differences were exceedingly small and did not favor either group consistently. This indicates that the validation trainees did not differ radically from their contemporaries trained conventionally.

TASK 18: SPECIFY MANHOURS EXPENDED AND CONVERSION COSTS

A total of 5615 manhours were expended in developing the individualized instructional materials for selected segments of Blocks IV and VI and for Block X of the PME course. A total of 71 contact hours of instruction were produced (36 hours of programmed text and 35 hours of mediated (AV) instruction). The total number of manhours expended on each task in the materials development process is shown in Table 4. The mean number of manhours expended per contact hour of instruction was 79. For programmed text, the mean number of manhours expended per contact hour was 65. For mediated (AV) instruction, the mean number of manhours expended per contact hour was 94.

In addition to the manhours expended in implementing Block X in a self-paced mode, it is possible to enumerate the costs associated with converting the conventional classroom into a configuration capable of supporting individualized instruction. A total of 15 individualized instruction stations were set up, 6 performance stations, 6 study stations, and 3 preview-remediation stations.

Each performance station contained all of the electronic test equipment appropriate for PME skill lessons. It also contained an Audiscan device, an A. B. Dick device, an equipment photo book, a set of AV scripts, and a full complement of Audiscan and A. B. Dick cassettes. Each performance station, then, was an independent unit - it contained all of the resources necessary to complete the skill lessons. The cost of setting up a performance station was as follows:

Audiscan Device	(1 @ $280.00)	$ 280.00
Audiscan Cassettes	(22 @ $20.00 each)	420.00
A. B. Dick Device	(1 @ $290.00)	290.00
A. B. Dick Cassettes	(8 @ $25.00 each)	200.00
Equipment Photo Book	(1 @ $90.00)	90.00
AV Scripts	(1 Set @ $20.00)	20.00
		$1300.00

TABLE 4

MANHOURS EXPENDED PER TASK

		MANHOURS EXPENDED
Phase I		
1.	Develop Segment Selection Criteria	20
2.	Review & Analyze Job Documents	80
3.	Isolate Trainee Characteristics	40
4.	Examine Training Environment	40
5.	Select Segments	40
		220
Phase II		
6.	Conduct Training Analysis	1140
7.	Review Learning Objectives	200
8.	Update Test Items	200
9.	Specify Sequence	120
10.	Specify Presentation Strategies	40
11.	Develop Media Selection Rationale	40
12.	Select Media	40
		1780
Phase III		
13.	Prepare Materials	
	Programmed Instruction	940
	Audio-Visual	1180
14.	Develop Management Plan	40
15.	Delineate Computer Adaptation Rationale	40
		2900
Phase IV		
16.	Describe Formative Evaluation Process	80
17.	Evaluate the Materials	555
18.	Specify Manhours Expended and Conversion Costs	80
		715
	Total Manhours Expended	5615

The 6 performance stations were supported by a performance "spares" station that had the following inventory:

Audiscan Device	(1 @ $280.00)	$ 280.00
Audiscan Cassettes	(9 sets @ $420.00 each)	3780.00
A. B. Dick Device	(1 @ $290.00)	290.00
A. B. Dick Cassettes	(9 sets @ $200.00 each)	1800.00
AV Scripts	(9 sets @ $20.00 each)	180.00
		$6330.00

There were no spares for the electronic test equipment.

Each study station contained the 5 programmed instruction (PI) texts appropriate for Block X. It also contained an equipment photo book and a set of AV scripts. The cost of setting up a study station was as follows:

Five PI Texts	($50.00 each)	$250.00
Equipment Photo Book	(1 @ $90.00)	90.00
AV Scripts	(1 set @ $20.00)	20.00
		$360.00

Nine extra copies of each of the 5 PI texts were available for individual study after normal classroom hours (Cost = $2250.00).

Each preview-remediation station contained a videotape recorder/player and monitor, a full complement of videotapes, an equipment photo book, and a set of AV scripts. The cost of setting up a preview-remediation station was as follows:

Videotape Recorder/Player	(1 @ $860.00)	$ 860.00
Videotape Monitor	(1 @ $335.00)	335.00
Videotapes	(26 @ $24.00 each)	624.00
Equipment Photo Book	(1 @ $90.00)	90.00
AV Scripts	(1 set @ $20.00)	20.00
		$1929.00

No hardware or courseware spares were available for preview-remediation stations.

The total cost of converting the conventional classroom into an individualized instruction center was as follows:

6 Performance Stations	($1300.00 each)	$ 7800.00
Spares Station	($6330.00)	6330.00
6 Study Stations	($360 00 each)	2160.00
Study Spares Station	($2250.00)	2250.00
3 Preview-Remediation Stations	($1929.00 each)	5787.00
		$24327.00

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

The reduction in training time achieved with the prototype self-paced materials argues strongly for the feasibility of individualizing the PME course as part of the AIS. Achievement as measured by criterion-reference checks and the end-of-block examination was well above the acceptable minimum, and trainee attitudes toward the materials were highly favorable. Most importantly, the trainees in the self-paced groups, unlike their counterparts in conventional instruction, were able to work alone at performance stations. Each trainee was able to get "hands-on" experience with each of the major equipments, and performance testing was more rigorous and standardized to a greater degree than it was in conventional training.

The model for designing, developing, and evaluating self-paced materials, described in Sections II, III, IV, and V of this report, is currently being revised and extended to provide guidelines for AIS materials development efforts. Moreover, the model as described would seem to be applicable to a wide variety of materials development efforts that have as their aim the design, development and evaluation of self-paced, multimedia training materials. Its point of departure is a reliable and thorough body of job tasks documentation. Consequently, those interested in applying the model in areas where job documentation does not exist or is suspect in terms of completeness or accuracy should realize that a significant amount of additional "hard work" will be required.

The prototype instructional materials developed in the context of this contract are amenable to computer management for eventual use as part of the integrated AIS. When the test scoring, prescription, resource allocation, and report generation programs described in Section IV become operational, Block X materials and resources can be placed under computer control.

No significant problems were encountered in any of the following areas: personnel requirements or procedures; equipment requirements or procedures; instructional management; or integration of system elements. The following observations and recommendations in these and related areas are, however, noted for your information.

1. Technical coordination proved difficult and time-consuming. Initially, task analysis documentation, learning objectives, test items, programmed texts, and scripts were mailed to the PMEL. This introduced a 4 to 7 day delay between completion of tasks by contractor personnel and the commencement of technical review by PME Master Instructors. Documentation and instructional materials were critiqued

and revisions negotiated via telephone conferences between the Master Instructors and contractor personnel. Lack of face-to-face contact led to misunderstandings and some unnecessary duplication of effort. The eventual substitution of site visits for the telephone conferences alleviated the problems associated with the mail-out and telephone critique procedures.

For small-scale development efforts, we recommend frequent site visits for coordination, review, and revision of training documentation and prototype materials. For large-scale development efforts, we recommend physical colocation of resource and contractor personnel.

2. Two instructors were required to handle the instructional management functions during small-group tryout and large-group validation. The eventual automation of several of those management functions will allow a single instructor to handle an even greater number of trainees under AIS than he currently handles in conventional instruction.

   Manual management of self-paced instruction is not a trivial matter. We recommend that provisions be made early in the materials design and development cycle for defining the new duties that the instructor will assume under a self-pacing configuration. Procedures and tools for accomplishing new duties may then be proposed, refined, and solidified prior to field testing the prototype materials.

3. A separate room was set aside for administration of the end-of-block examination. Normal classroom noises and other potential distractions would have worked an unnecessary hardship on trainees being tested.

   We recommend that separate rooms be utilized for instruction and testing in self-paced configurations. If space limitations prohibit the use of two rooms, some practical means of isolating trainees who are being tested from those engaged in instructive activities should be devised (e.g., semi-enclosed testing carrels).

4. The removal of electronic equipment from performance stations for repair and calibration caused delays and necessitated trainee re-routing during small-group tryout and large-group validation.

   We recommend acquiring a minimum of one back-up unit for each major piece of equipment. If funds are limited, equipment reliability, maintainability, and frequency of usage data can be utilized in selecting for purchase as spares those pieces of equipment that, in the event of breakdown, have the greatest adverse impact on trainee flow through the materials.

5. End-of-block examination scores were not as high as expected. The absence of formal end-of-lesson tests almost certainly served to depress the end-of-block examination scores. Comprehensive tests should be given at the end of "knowledge" lessons. The possibility of inserting a review test at the end of the lesson to provide trainees with feedback and the opportunity to remediate prior to taking the end-of-lesson test should also be considered.

6. Instructors and trainees agreed that some of the longer programmed instruction lessons were monotonous and boring.

   Programmed lessons that require more than one hour of uninterrupted reading should be divided and the new packages should not be presented sequentially. A brief review or introduction on a different presentation medium can be inserted to avoid the boredom that results from reading for long periods of time.

7. The decisions to use motion pictures for certain of the "skill" lessons was based primarily on our desire to implement more than one AV medium in the feasibility study, and only secondarily on our belief that motion had special pedagogical value in the context of those lessons for which it was utilized.

   In a production, rather than R & D, configuration the decision to use motion pictures should be based on a detailed analysis of lesson objectives, task characteristics, and a learning proficiency-production cost trade-off.

8. Audiscan courseware failures, due to poor filmstrip splicing, were numerous.

   Great care should be exercised in splicing the filmstrips prior to inserting them into the Audiscan cartridge. Quality control procedures that require inspection of each spliced filmstrip or a periodic spot check of a sample of spliced filmstrips would insure a significant decrease in the number of classroom failures. A further recommendation calls for investigating the utility of sound/filmstrip devices that can be manually paced by the trainee, forward or backward, without destroying the synchronicity of picture and sound. Finally, headsets and footswitches should become integral components of the presentation device. Headsets make for quieter classrooms, and footswitches allow trainees to control AV programs without affecting their performance on two-handed tasks.

9. Trainees were not able to use the STOP feature of the A. B. Dick projector. In those instances when the STOP feature was used, a relay overheated and the film would not advance upon restart.

   If the A. B. Dick projector is to be used, it should be used as a continuous presentation device; i.e., the STOP feature should be deactivated or trainees should be told not to activate it.

APPENDIX A

SAMPLE TASK ANALYSIS
FREQUENCY COMPARISON USING LISSAJOUS PATTERNS

STEP

1 Secure all loose clothing and remove all rings, watches, and other objects that could act as conductors of electricity and cause shock or electrocution.

2. Insure that the TEK-545 POWER switch is OFF and that TEK TYPE CA Plug-In Unit is installed in the TEK-545.

3. Connect the TEK-545, HP-205AG, and HP-202A power cords to sources of 117 volt, 60 Hz power.

4. Set the HP-205AG AMPLITUDE control to the 0 position and turn the POWER switch to ON.

5. Set the HP-202A AMPLITUDE control fully CCW and turn the POWER switch to ON.

6. Set the TEK-545 front controls as follows:

a. INTENSITY	- CCW
b. FOCUS	- Center
c. ASTIGMATISM	- Center
d. HORIZONTAL POSITION	- Center
e. POWER	- On
f. HORIZONTAL DISPLAY	- Ext. Sweep

Main Sweep

a. TRIGGERING LEVEL	- CW
b. STABILITY (Red Knob)	- CW
c. TRIGGER SLOPE	- + Ext
d. TRIGGERING MODE (Red Knob)	- DC
e. TIME/CM	- 10 Millisec
f. MULTIPLIER	- 5
g. 5X MAGNIFIER	- Off

7. Set controls of CA Plug-In Unit as follows:

Channel A

a. AC/DC SWITCH	- AC
b. POLARITY	- Normal
c. VERTICAL POSITION	- Center
d. VOLTS/CM	- 20
e. VARIABLE	- Calibrated
f. MODE SWITCH	- A Only

Channel B

a. AC/DC SWITCH - AC
b. POLARITY - Normal
c. VERTICAL POSITION - Center
d. VOLTS/CM - 20
e. VARIABLE - Calibrated

8. Set the controls of the HP-205AG Audio Signal Generator as follows:

a. FREQUENCY - 60 Hz
b. NO ATTENUATION
c. IMPEDANCE SWITCH - "5000"
d. LOAD SWITCH - On

9. Advance HP-205G AMPLITUDE CONTROL until the OUTPUT METER indicates 20V.

10. Set the HP-202A, Low Frequency Function Generator as follows:

a. AMPLITUDE control to 20
b. FREQUENCY dial to 3
c. RANGE to X 10
d. FUNCTION SELECTOR - Sine

11. Turn the INTENSITY control clockwise until you see a trace on the screen.

12. Set FOCUS, INTENSITY, and ASTIGMATISM for a sharp line.

13. Position the trace near the center of the screen with the Channel A VERTICAL POSITION control and the HORIZONTAL POSITION control.

14. Connect a cable from the HP-205AG OUTPUT jack to the TEK-545 Channel A INPUT jack, and the Main Sweep TRIGGER INPUT jack.

15. Adjust for 4 CM of vertical deflection, on Channel A, with the VOLTS/CM and VARIABLE controls.

16. Using the HORIZONTAL POSITION control center the straight vertical line horizontally.

17. Disconnect the cable from the Channel A INPUT jack.

18. Connect a cable from the HP-202A OUTPUT jack to the TEK-545 EXT. SWEEP IN jack.

19. Adjust the straight horizontal line for 4 CM of deflection using the EXT. SWEEP ATTEN. Control. It may be necessary to change the position of the ATTEN switch to obtain the 4 CM of deflection.

20. Using the Channel A VERTICAL POSITION control center the trace vertically.

21. Reconnect the cable from the HP-205AG OUTPUT jack to the Channel A INPUT jack.

22. Stabilize the sweep using the HP-202A FINE FREQUENCY control.

23. Record Frequency Ratio, where:

    Frequency Ratio = Vertical Deflection in CM: Horizongal Deflection in CM

    Frequency Ratio = ______________.

24. With the HP-205AG and the HP-202A at the following settings, record the Frequency Ratio.

	HP-205AG Setting	HP-202A Setting	Frequency Ratio
a.	90 Hz	30 Hz	________
b.	120 Hz	30 Hz	________
c.	150 Hz	30 Hz	________
d.	90 Hz	60 Hz	________

25. Turn the TEK-545, HP-205AG, and HP-202A POWER switches to OFF and disconnect all cables.

SAMPLE CONTENT ANALYSIS

TEK-545 OSCILLOSCOPE: FRONT PANEL CONTROLS AND CONNECTORS

Main Sweep

a. Triggering Mode (Red Knob)

(1) Five-position switch
(2) Arranges trigger circuits for five kinds of triggering

(a) HF SYNC
(b) AUTOMATIC
(c) AC FAST
(d) AC SLOW
(e) DC

b. TRIGGER SLOPE

(1) Six-position switch
(2) Selects source of trigger signal

(a) EXT + or -
(b) INT + or -
(c) LINE + or -

c. TRIGGER INPUT

(1) UHF Coax Connector
(2) External Triggering input

d. STABILITY (Red Knob)

(1) Four possible positions or regions
(2) Adjusts sweep circuits for stable display

(a) Free Running
(b) Triggerable
(c) Locked Out
(d) Preset

e. TRIGGERING LEVEL

(1) Potentiometer
(2) Determines the point, on the signal under test, where the sweep will start or trigger.

f. TIME/CM

(1) Eight-position switch - .1 μsec to 1 sec/cm
(2) Determines sweep speeds
(3) Determines duration of trigger holdoff period

g. MULTIPLIER

(1) Six-position switch
(2) Three positions determine sweep speeds with selected timing capacitor - X1, X2, and X5
(3) Three positions, in red, allow for continuous control of sweep speeds - 1-2.5, 2-5, and 5-12

h. 5X MAGNIFIER

(1) Two-position switch (on/off)
(2) Change sweep speeds by factor of five
(3) Magnifies the presentation between the 4th and 6th

i. + GATE

(1) Connector
(2) Supplies 20 volt positive pulse in synchronization with the main sweep

j. SAWTOOTH

(1) Connector
(2) Supplies 150 volt positive going sawtooth

<u>Delaying Sweep</u>

a. STABILITY (Red Knob)

(1) Three regions
(2) Adjustment of multivibrator
(3) Adjusts bias for recurrent or triggered sweep

(a) Free Running
(b) Triggerable
(c) Locked Out

b. TRIGGERING LEVEL

(1) Potentiometer
(2) Determines the point, on the signal under test, where a sweep will start or trigger

c. TIME/CM

(1) Twelve-position switch
(2) Selects twelve fixed sweep speeds - 2 μsec to 10 msec/cm

d. LENGTH (Red Knob)

(1) Sweep length control
(2) Permits delaying sweep to be reverted immediately to increase duty cycle
(3) Normally left at 10 cm

e. DELAY-TIME MULTIPLIER

(1) Ten-turn helical resistor (helipot)
(2) Determines timing of delayed trigger

f. RESET MAIN SWEEP

(1) Pushbutton
(2) Arms main sweep triggering circuit

g. DELAYED TRIGGER

(1) Connector
(2) Supplies delayed trigger from main sweep or from delaying sweep

h. + GATE

(1) Connector
(2) Supplies 20 volt positive pulse in synchronization with delaying sweep

i. SLOPE + or

(1) Toggle switch
(2) Selects in or out-of-phase output for triggering sweep gating multivibrator
(3) Selects polarity for external sweeps

j. ATTEN, X1, X10

(1) Toggle switch
(2) Inserts or bypasses 10:1 compensated attenuator in delaying-sweep trigger input or external circuits

k. EXT SWEEP ATTEN (Same as D.S. STABILITY)

(1) Control
(2) Gain control for horizontal amplifier
(3) Not used with internal sweeps

l. TRIGGER OR EXT SWEEP IN

(1) Connector
(2) Input to horizontal amplifier
(3) 5X MAGNIFIER must be ON when used for EXT SWEEP

Additional Controls

a. HORIZONTAL DISPLAY

(1) Four-position switch
(2) Arranges sweep circuits for displays of:

(a) Main Sweep Normal
(b) Delaying Sweep
(c) Main Sweep Delayed
(d) EXT Sweep

b. HORIZONTAL POSITION

(1) Potentiometer
(2) Positions trace

c. VERNIER (Red Knob)

(1) Potentiometer
(2) Fine horizontal position control

Other Outputs

a. SQUARE-WAVE CALIBRATOR (Red Knob)

(1) Three-position switch
(2) Voltage divider to give either VOLTS or MILLIVOLTS output

b. SQUARE-WAVE CALIBRATOR (Black Knob)

(1) Nine-position switch
(2) Provides nine accurate peak-to-peak voltages or millivolts position of the red knob. .2 to 100 VOLT or MILLIVOLT

c. CAL OUT

(1) UHF connector
(2) Provides SQUARE-WAVE CALIBRATOR output voltages

d. CAL OUT

(1) UHF connector
(2) Provides SQUARE-WAVE CALIBRATOR output voltages

d. VERT SIG OUT

(1) Connector
(2) Supplies a sample of the vertical-deflection signal

e. 6.3V AC

(1) Connector
(2) Provides output of 6.3 VAC from oscilloscope power transformer

<u>Auxiliary Controls</u>

a. POWER

(1) Toggle Switch
(2) Power ON/OFF control

b. FOCUS

(1) Potentiometer
(2) Controls voltage to CRT focusing grid

c. INTENSITY

(1) Potentiometer
(2) Bias control of CRT control grid

d. ASTIGMATISM

(1) Potentiometer
(2) Controls voltage to CRT astigmatism grid

e. SCALE ILLUM

(1) Potentiometer
(2) Controls current through graticle lights

APPENDIX B

SAMPLE LEARNING OBJECTIVE

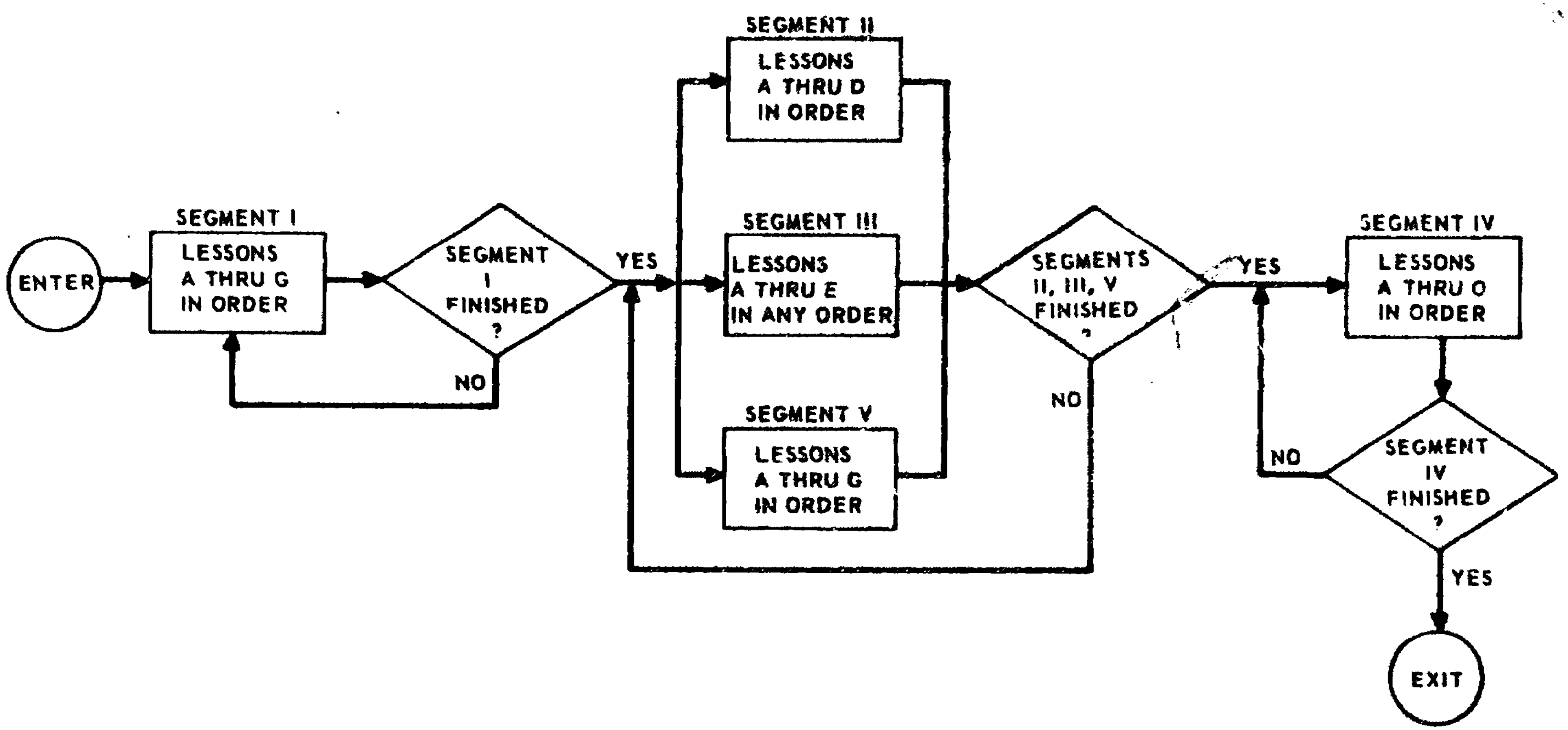
Given the appropriate manual and technical orders and test equipment, the trainees will make five frequency comparisons using Lissajous patterns, record each frequency ratio, and commit no errors of practical significance.

GIVEN

AFM 127-101
T.O. 33A1-13-73-1
T.O. 31-1-141-1 through 18

TEK-545 with TEK TYPE CA Plug-In Unit installed
HP-205AG
HP-202A
Appropriate power cords

APPENDIX C



LESSON FLOWCHART

APPENDIX D

TRAINEE NAME		SEGMENT I						SEGMENT IV			
	STATUS CODE	LESSON A	LESSON B	LESSON C	LESSON D	LESSON E	LESSON F	LESSON L	LESSON M	LESSON N	LESSON 0
	START END										
	START END										
	START END										
	START END										

TRAINEE PROGRESS FLOWCHART

APPENDIX E

INSTRUCTIONAL [illegible] ...IRE

Date ____________

DIRECTIONS: Below are several statements about the course of instruction you have just completed. Respond to each statement with <u>how you felt</u> while participating in this instruction.

There are no right or wrong answers. Read each statement carefully and indicate how much you agree or disagree.

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
1. I would like more instruction presented in this way.	1	2	3	4	5
2. I learned more because these instructional materials were available for me to use.	1	2	3	4	5
3. This instruction was very boring.	1	2	3	4	5
4. In view of the time allowed for learning, I felt that too much material was presented.	1	2	3	4	5
5. I became easily discouraged with this type of instruction.	1	2	3	4	5
6. There are too many distractions with this method of instruction.	1	2	3	4	5
7. I felt that I wanted to do my best work while taking this instruction.	1	2	3	4	5
8. This method of instruction makes learning too mechanical.	1	2	3	4	5
9. This is a poor way for me to learn skills.	1	2	3	4	5

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
10. This method of instruction does not seem to be any better than other methods of instruction.	1	2	3	4	5
11. It was hard for me to follow the order of this instruction.	1	2	3	4	5
12. I felt uncertain as to my performance in the instruction.	1	2	3	4	5
13. There was enough time to learn the material that was presented.	1	2	3	4	5
14. I don't like this instruction any better than other kinds I have had.	1	2	3	4	5
15. This was a very good way to learn the material.	1	2	3	4	5
16. While taking this instruction I felt challenged to do my best work.	1	2	3	4	5
17. Answers were given to the questions that I had about the material.	1	2	3	4	5
18. I seemed to learn very slowly with this type of instruction.	1	2	3	4	5
19 This type of instruction makes me want to work harder.	1	2	3	4	5
20 I felt as if I had my own teacher while taking this instruction.	1	2	3	4	5

APPENDIX F

BLOCK X
SMALL-GROUP TRYOUT RESULTS

TRAINEE	TEST SCORE	DAYS SAVED	ATTITUDE
1	92	4	84
2	88	4	90
3	84	2	76
4	80	3	72
5	76	1	72
6	74	4	74
7	70	3	81
8	70	3	93
9	70	2	70
10	70	0	72
$\overline{X}$	77.4	2.6	78.4
Range	70-92	0-4	70-93

APPENDIX G

BLOCK X
LARGE-GROUP VALIDATION RESULTS

TRAINEE	TEST SCORE	DAYS SAVED	ATTITUDE
1	76	5	--
2	66	2	92
	76	-	--
3	80	6	84
4	70	3	75
5	92	4	85
6	88	5	100
7	82	3	79
8	92	3	75
9	72	3	74
10	82	2	68
11	84	5	73
12	78	6	--
13	92	4	--
14	84	4	--
15	70	4	73
16	70	3	72
17	70	4	60
18	72	7	95
19	94	5	76
20	80	4	88
21	92	6	78
22	80	6	71
23	84	5	79
24	74	3	84
25	80	4	83
26	96	7	100
27	70	6	69
28	82	6	68
29	80	6	66
30	82	9	81
31	92	6	65
32	78	4	67
33	68	4	74
	82	-	--
34	68	5	62
	88	-	--
35	84	2	84
$\bar{X}$	80.1	4.6	77.4
Range	66-96	2-9	60-100

APPENDIX H

TRAINEE BACKGROUND DATA

		$\bar{X}$	$\bar{X}$	$\bar{X}$ Test Scores		
	n	Gen AQE	Elec AQE	Block I	Block X	Total
AIS	35	79.03	89.61	81.05	81.37	92.94
non-AIS	47	79.14	87.68	79.87	86.63	83.83